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Brakes	Drum torque	Mechanical winch	Overload device
Cable	Electric winch	Line speed	Pulley

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Describes the procedures for evaluating the performance and endurance of automotive winches that are accessory items on tracked and wheeled vehicles. Also included is soldier-maintainer testing and evaluation (SOMTE) in connection with the functional tests of winches, endurance and logistic supportability testing, and human factors evaluations. Winches associated with warehouse cranes are covered by TOP 9-2-063; and those with power cranes and shovels are covered by MTP 9-2-064.

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U.S. ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

AMSTE-RP-702-101
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AUTOMOTIVE WINCHES

1. SCOPE. This TOP describes the procedures for evaluating the performance and endurance of automotive winches that are accessory items on tracked and wheeled vehicles. Also included are soldier operator-maintainer testing and evaluation (SOMTE) in connection with functional tests of winches, endurance testing, logistic supportability testing, and human factors evaluation. Winches associated with warehouse cranes are covered in TOP 9-2-063;[a] and those with power cranes and shovels are covered in MTP 9-2-064.[b]

*This TOP supersedes TOP 2-2-712 dated 27 June 1975.

[a]Footnote letters/numbers match those in Appendix B, References.

2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities.

ITEM	REQUIREMENTS
Dynamometer	To test winch loading capabilities
Mud course	To test winch moving vehicles from mud
Longitudinal slopes	To test winch self-recovery capabilities

2.2 Instrumentation.

DEVICES FOR MEASURING	PERMISSIBLE ERROR OF MEASUREMENT*
Time (e.g., stopwatch)	±0.1 second
Winch pull (e.g., strain-gaged load cell)	±1%
Oil pressure (e.g., gage, transducer)	±2% of full scale
Petroleum, oil, lubricant temperatures (e.g., thermocouples)	±1 °C
Motor current (e.g., shunt)	±5%
Motor voltage (e.g., digital voltmeter)	±2%

*Values may be assumed to represent ±2 standard deviations; thus the stated tolerances should not be exceeded in more than 1 measurement of 20.

3. REQUIRED TEST CONDITIONS.

3.1 Preliminary Activities.

a. Check the winch cable (wire rope) to ensure that the proper diameter is being used to safely handle the loads specified for the winch. The ratio by which the rated breaking strength of the cable should exceed the capacity of the winch is the safety factor. This safety factor should be determined and compared to the prescribed safety factor before any loads are applied to the cable. In lieu of guidance, the cable should have a minimum safety factor of 2:1. Nominal (design) breaking strengths for various types, classes, and sizes of wire rope are specified in Federal Specification RR-W-410.[1]

b. Check snatch blocks, pulleys, and drums to be sure that they are correct for the designated cable type and size, as well as load, and that they are in suitable operating condition.

c. Record drum length and diameter, cable length and diameter, winch capacity, cable capacity, and the number of cable layers on the drum.

d. Also measure and record the increase in vehicle length, the decrease in angle of departure or approach (as appropriate to winch location), and weight distribution. Information will be used to determine changes due to the addition of the winch to the vehicle.

e. Service and adjust the vehicle including the governor, brakes, clutches and tire pressure or track adjustment as recommended by the manufacturer.

f. Install suitable instrumentation to measure the pertinent parameters. Of particular importance are ambient air temperature and weather conditions throughout all test phases.

3.2 Test Conditions.

a. During the test, maintain the engine and test components such as winches, boom, spade, traversing mechanisms, level winding devices, and winch and cab-traversing brakes in the proper operating condition.

b. Avoid extreme shock loads during the conduct of these tests, and disregard test results if winch failure occurs because of such loads.

c. Whenever the condition of the cable precludes additional test operations, suspend testing until a replacement cable is installed.

d. In hydraulic winches, line pull must not exceed the limit established in the applicable vehicle specification for the hydraulic relief valve control.

e. The hydraulic system shall operate satisfactorily using the oils specified, and shall not be operated when the hydraulic reservoir oil exceeds 77°C (170°F) or other specified temperature.

f. Before each test, operate the winch system at part load for a sufficient period of time to ensure that it is fully warmed up. After this warm-up period, recheck the various adjustments to ensure that they are within tolerances.

g. During the test, take all necessary safety precautions. Snatch blocks may fail and be thrown great distances, or cables may fail and whip around any nearby object. Test personnel must wear gloves, safety hats, and safety shoes.

3.3 Safety Evaluation. Safety evaluation is normally conducted as part of the safety evaluation of the vehicle in accordance with AMC Regulation 385-100[2] and TOP 2-2-508.[3]

a. Controls for the winch must provide the operator with convenient and safe winch operation.

b. Adequate guards or shields must be provided to protect the operator should a cable fail, particularly when the controls are located near the winch.

c. The cable must be of a size and type that will provide an adequate factor of safety (para 3.1a) along with pulleys, snatch blocks, and other winch-related items.

d. Moving parts that may become a hazard to operating personnel should be fully enclosed or properly guarded.

e. Safety observations should be made during the engineering and SOMTE phases of testing, and also evaluate safety during night operations.

f. All hazards shall be categorized in accordance with MIL-STD-882B[4] and classified in accordance with TOP 1-1-012.[5] All safety-related data shall be reported in the safety and health section of the test report.

4. TEST PROCEDURES. In addition to meeting the specified requirements for the winch, the complete winch system must meet the applicable requirements of the vehicle specification.

4.1 Line Speed.

a. Method. Determine winch line speeds (for all type winches) with the engine speed at the specified value for winch operation and the cable loaded to 25, 50, 75, and 100% of the rated winch capacity.

b. Data required.

(1) Obtain line speeds by timing a mark on the cable as it passes two stakes suitably spaced.

(2) As a minimum, measure line speed for the bare-drum and full-drum cable layers versus engine speed.

(3) Make a sufficient number of test runs to provide repeatable data.

(4) For each test run, calculate and compare the average line speed for winching all layers to specifications.

(5) Determine or calculate a line speed for each drum speed when multiple drum speeds are provided through varying gear ratios.

4.2 Winch Capacity and Brakes.

a. Method.

(1) Accomplish load-capacity tests with the vehicle anchored and all but the last three turns of cable unwound from the main winch drum.

(2) Attach the cable to a dynamometer or other suitable loading device.

(3) While winding the first layer of cable, increase the load until the overload safety device functions, or if the winch is not equipped with such a device, until the maximum rated capacity or overload value is reached.

(4) At this time, check the automatic mechanical brake for its ability to stop and hold the load for 5 minutes after the removal of winch drive power.

b. Data required.

(1) Measure and record winch pull to actuate the overload device (or to reach the overload value) and the distance from the center of the winch drum to the center of the cable leading from the drum (torque arm).

(2) Also record the hydraulic oil pressure and temperature observed during the test for hydraulic winches and the motor current and voltage for electric winches.

(3) On new items, or as required, determine the winch line pull to actuate the overload device and the corresponding torque arm for each cable layer. (Use the measured diameter to calculate the torque arm.)

4.2.1 Overload Test. Winch overload protection devices are characteristically inaccurate and may impose loads in excess of the rated capacity on the winch, particularly mechanically driven winches that use a shear pin for overload protection. The ability of the winch to withstand inadvertent overloading is determined by applying a test load 1.25 times the rated winch capacity while winding the first cable layer on the drum. For this test, the overload device is modified or adjusted to accommodate the increase in loading.

4.2.2 Drum-torque Calculation. The drum torque is equal to the actual line pull in newtons (pounds) multiplied by the torque arm length in centimeters (inches). Determine the bare-drum torque for the rated capacity of the winch. Using this torque value and the previously determined torque arms, calculate the rated line loads for each cable layer.

4.3 Functional Tests of System Components.

4.3.1 Boom.

a. Method.

(1) For systems that have a boom, raise (or extend) the boom, without a load, from its travel position to maximum height (or length), and then return the boom to the travel position.

(2) Determine the ability of the boom to lift, move, and lower the specified weights with the spade emplaced or stowed per specification.

b. Data required. Compare boom lift height/length and the times required to raise and lower (or extend and retract) the boom with vehicle specification requirements.

4.3.2 Spade. Evaluate the spade hoisting system for ability to stabilize the vehicle when winching or hoisting maximum specified loads and for ability to raise the spade to stowed position within the time limit specified.

4.3.3 Cab Traversing and Braking. When appropriate, check the ability of movable cabs, turrets, or other crew compartments to traverse with the specified loads on the boom, with the spade stowed or emplaced on level ground or specified side slope, for compliance with the position, and determine the ability of the traverse brake to stop and prevent cab rotation.

4.3.4 Level Wind Device. Evaluate the ability of the level wind device to provide proper wrapping of the cable under full load throughout the winch tests.

4.4 Functional Tests of Winches. Conduct functional tests of winches under the following conditions:

a. Method.

(1) Perform functional test of vehicle on 60% slope by using a suitable anchor for the cable end and employing the winch to pull the vehicle with maximum payload up a representative portion of the slope.

(2) Also the winch may be tested under conditions (such as in deep mud) that immobilize the vehicle. Using another vehicle or tree as an anchor, extricate the immobilized vehicle under its own power.

(3) In some instances it may be desirable to use the winch to right an overturned vehicle, recover an immobilized vehicle, or to tow a vehicle over unpaved roads or various test courses.

b. Data required. Make observations regarding safety, suitability, and ease of operation.

4.5 Endurance Testing. Conduct endurance tests of winches according to the intended application of the winch. In general, these tests consist of repeating winch operation for a prescribed number of test cycles in the manner described for the particular winch type. During these tests, a test cycle is not started when it is obvious that overheating of a winch system would occur before completion of the cycle. This would usually occur at 146°C (300°F) for the winch gearcase oil and 77°C (170°F) for the hydraulic oil. The endurance test is used, in part, to acquire data for the logistic supportability test and human factors evaluation (para 4.6 and 4.7) and for assessing safety.

4.5.1 Engineering Phase. For each test described below, record the applied line loads (and pressures for hydraulic winches, motor current and voltage for electric winches), time duration, engine speed, and gearcase hydraulic oil or motor temperatures. At test completion, examine the winch drum for distortion or necking down and elongation.

4.5.1.1 Front-mounted Winches. The endurance test for front-mounted winches consists of up to 50 cycles of winch operation with at least two cycles being conducted without resting the winch. The total number of cycles to be performed will be determined from predicted winch usage or the test-vehicle requirements document. Each cycle will consist of reeling in, at a minimum, 100 feet of cable with the load adjusted to 100% of the load capacity for each particular layer. If the winch fails to complete a cycle due to overheating or protective device activation, reduce the load in increments of 10% of capacity until a full cycle can be completed. Disengage the applied load before the cable is payed out for the next cycle.

4.5.1.2 Mid- and Rear-mounted Winches. Determine endurance in the same manner as for front-mounted winches except that up to 100 cycles of operation are completed.

4.5.1.3 Boom Hoist Winches (Nonrotating). Determine winch endurance by repeating the winch duty cycle, with periods of rest between cycles until 8 hours of actual winch operation are accumulated. The winch duty cycle consists of hoisting and lowering the maximum rated load to and from the height specified. Each duty cycle is followed by a rest period equal to the duty cycle time. Rest period time is not counted toward operation time.

4.5.1.4 Boom Hoist Winches (Traversing). The endurance test for these winches consists of 40 hours of operation divided into 20 2-hour lift cycles that are conducted periodically during the vehicle endurance test. A typical lift cycle would consist of the following sequence:

a. Handling the maximum permissible load at maximum boom reach for 40 minutes.

b. Handling the maximum permissible load at an intermediate boom reach for 40 minutes.

c. Lifting a load at the maximum rated capacity of the crane with or without boom jacks for 40 minutes.

4.5.1.5 Crane Winches. Determine the endurance of winches used for materials-handling cranes on cargo vehicles by conducting 125 cycles of loading and unloading the vehicle payload periodically during the vehicle endurance test. Conduct six cycles without resting the winch. During these six cycles, the crane system components must not overheat.

4.5.2 SOMTE Testing.

a. Method. The hours of testing will not be less than that of endurance testing during the engineering phase. When a mission profile is given, SOMTE testing involves repeated simulations of the missions. If the mission profile is not provided, SOMTE testing will consist of repeated practical missions as described in paragraph 4.4.

b. Data required. Record the following:

(1) Type and weight of the vehicles recovered.

(2) Distance a vehicle is towed.

(3) Percent of slope of ravine or ditch.

(4) Method used in each recovery operation.

(5) Inadequacies of soldier/equipment interactions.

(6) Training inadequacies.

4.6 Logistic Supportability Testing.

a. Obtain data for logistic supportability throughout all testing of winches (both engineering and SOMTE phases), particularly during the endurance tests.

b. Tabulate data on the hours of operation, the failures that occur, the type and hours of preventive maintenance performed, the adequacy of the maintenance manual, the nature of repairs, and the time and spare parts required for repairs.

4.7 Human Factors Evaluation. Obtain information for the human factors evaluation (HFE) throughout the engineering, SOMTE, and safety phases of testing. Obtain HFE guidance from TOP 1-2-610,[6] MIL-STD-1472C,[7] and MIL-HDBK-759A(MI).[8]

5. PRESENTATION OF DATA.

a. Record data using charts, tables, photographs, etc., as needed.

b. Analyze the data in accordance with AR 750-1[9] to determine such information as mean time to failure (MTTF) and mean time to repair (MTTR).

c. Compare recorded data with requirements documents.

Recommended changes to this publication should be forwarded to Commander, U.S. Army Test and Evaluation Command, ATTN: AMSTE-TC-M, Aberdeen Proving Ground, MD 21005-5055. Technical information may be obtained from the preparing activity, Commander, U.S. Army Combat Systems Test Activity, ATTN: STECS-AD, Aberdeen Proving Ground, MD 21005-5059. Additional copies are available from the Defense Technical Information Center, Cameron Station, Alexandria, VA 22304-6145. This document is identified by the accession number (AD No.) printed on the first page.

APPENDIX A
BACKGROUND

Winches are used on a wide variety of military wheeled and track-laying vehicles. Depending upon the purpose and weight of the vehicle, the winches may employ electrical, mechanical, or hydraulic drives and vary in capacity.

Mechanical winches are relatively simple and meet the requirements for secondary accessories on many vehicles. Where winching is a major function, hydraulic winches are favored for wreckers and recovery vehicles, since they have the advantages of flexibility of location, superior controlability, and reduced requirements for heavy drive shafts and gearing. In some military vehicles, the hydraulic winch is only a component of an overall hydraulic system incorporating boom, spade, main and hoist winches, traverse mechanisms, suspension lockout, and level wind devices.

APPENDIX B
REFERENCES

Required References

1. Federal Specification RR-W-410D, Wire Rope and Strand, 25 April 1984.

2. AMC Regulation 385-100, Safety Manual, 1 August 1985.

3. TOP 2-2-508, Automotive Safety and Health Hazard Evaluation, 24 November 1982.

4. MIL-STD-882B, System Safety Program Requirements, 30 March 1984.

5. TOP 1-1-012, Classification of Deficiencies and Shortcomings, 1 April 1979; Change 1, 4 November 1981; Change 2, 26 November 1982; Change 3, 3 December 1985.

6. TOP 1-2-610, Human Factors Engineering (Part II - Human Factors Engineering Guide for Evaluation (HEDGE)), 30 November 1983.

7. MIL-STD-1472C, Human Engineering Design Criteria for Military Systems, Equipment and Facilities, 2 May 1981; Notice 1, 1 September 1983; Notice 2, 10 May 1984.

8. MIL-HDBK-759A, Human Factors Engineering Design for Army Materiel, 30 June 1981; Notice 1, 31 December 1985.

9. AR 750-1, Army Materiel Maintenance Concepts and Policies, 15 March 1983.

References for Information Only

a. TOP 9-2-063, Crane Truck, Warehouse, 8 January 1974.

b. MTP 9-2-064, Crane, Shovel, Tracked and Wheeled, 1 July 1971.